Electro-Optic Field Sensor

Project Number: 96-11

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Purpose

The purpose of this work is to develop an optical sensor for measuring thunderstorm electrostatic fields. The sensor will detect changes in the electric field (ΔE) due to lightning; in the future, it may be possible to detect the continuous field (E) with this sensor.

Background

Electric field measurements are fundamental to the study of atmospheric electricity and lightning research. Measurements of the changes in thunderstorm electrostatic fields (ΔE) can be used to determine the location of and charges deposited by lightning. Lightning produces power outages, forest fires, and is a hazard to aviation/space vehicle operations.

Approach

The approach taken is to shine a laser beam through an electro-optic crystal that is exposed to the ambient thunderstorm field, and relate the light transmission to the ambient field (figs. 36 and 37).

Accomplishments

In addition to completing fabrication of the optical housing (fig. 37), the primary accomplishment this past year has been in improving sensor signal-to-noise. This was done because of the following:

- Obtained an amplifier (SR570) with adequate input offset adjustment/gain/filters;
- Obtained more powerful (30 mW) laser diode to improve sensor performance;
- Ordered a larger aperture (20 mm) electro optic crystal to reduce optical noise; and
- Simulated lightning ΔE measurements.

The results of improvements 1 through 3 are shown in figure 38. The top plot is an early test of the sensor; there is considerable noise (the output should look like a square wave), and the sensor output amplitude is small (see vertical axis scale). The bottom plot was obtained after the above hardware improvements were made to the sensor. Note the low-noise, large-output amplitude.

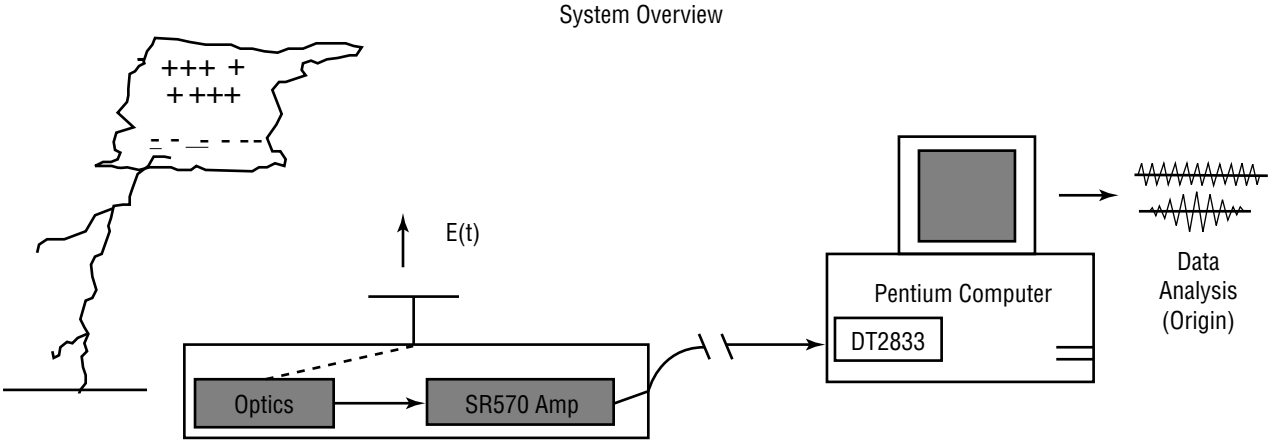


FIGURE 36.—Overview of the electro-optic field sensor (EFS); E(t) is lightning field change.

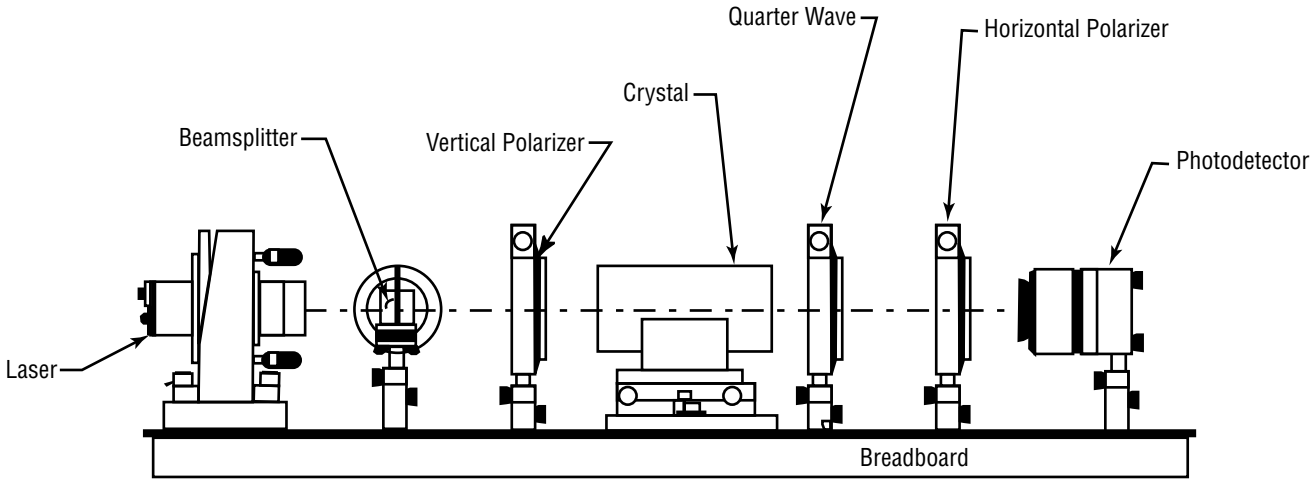
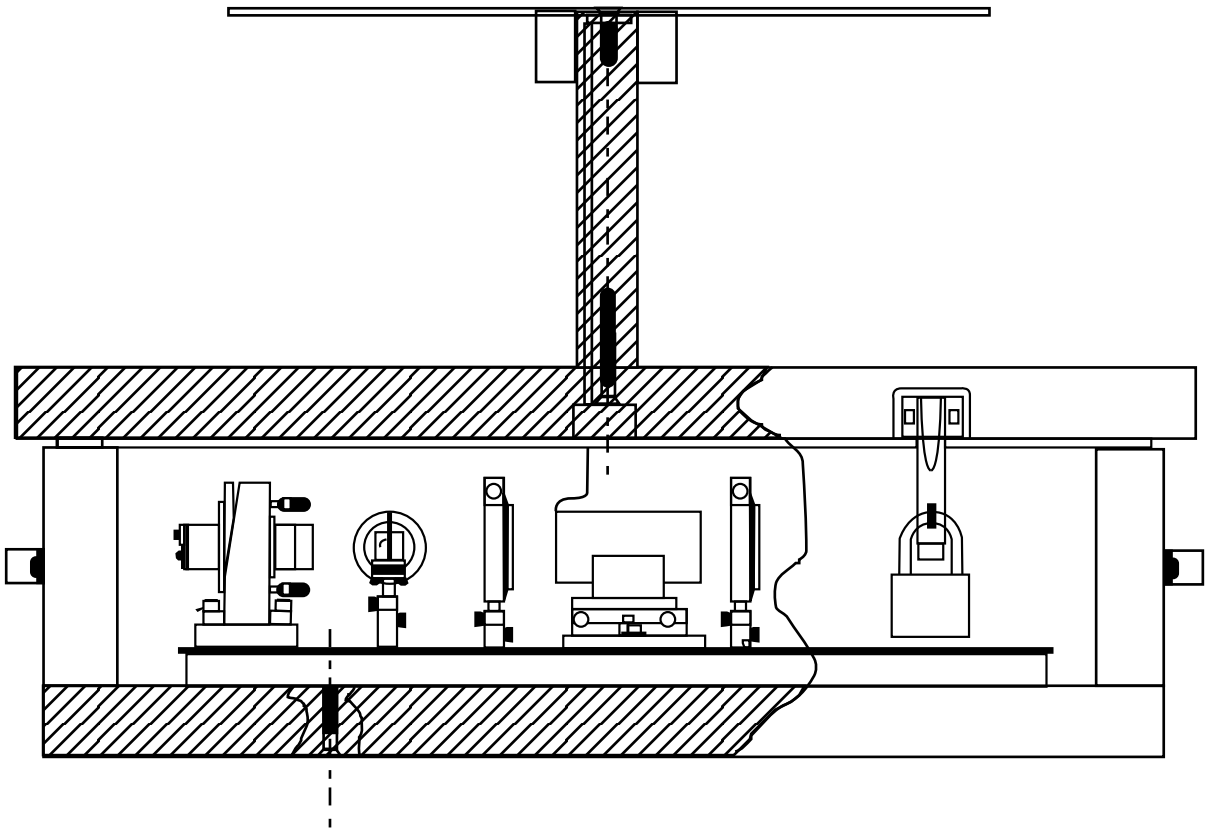


FIGURE 37.—Optics (top) and housing (bottom) for the electro-optic field sensor



Planned Future Work

- Significant near term events—integrate and test large-aperture crystal.
- General Plan—maximize sensor signal-to noise, explore continuous E-recording.
- Applications—build a miniature version of existing breadboard prototype.

Publications and Patent Applications

We submitted an abstract on electro-optic field sensor at the Fall meeting of the American Geophysical Union, San Francisco, California, December 8–12, 1997. No patents at this time.

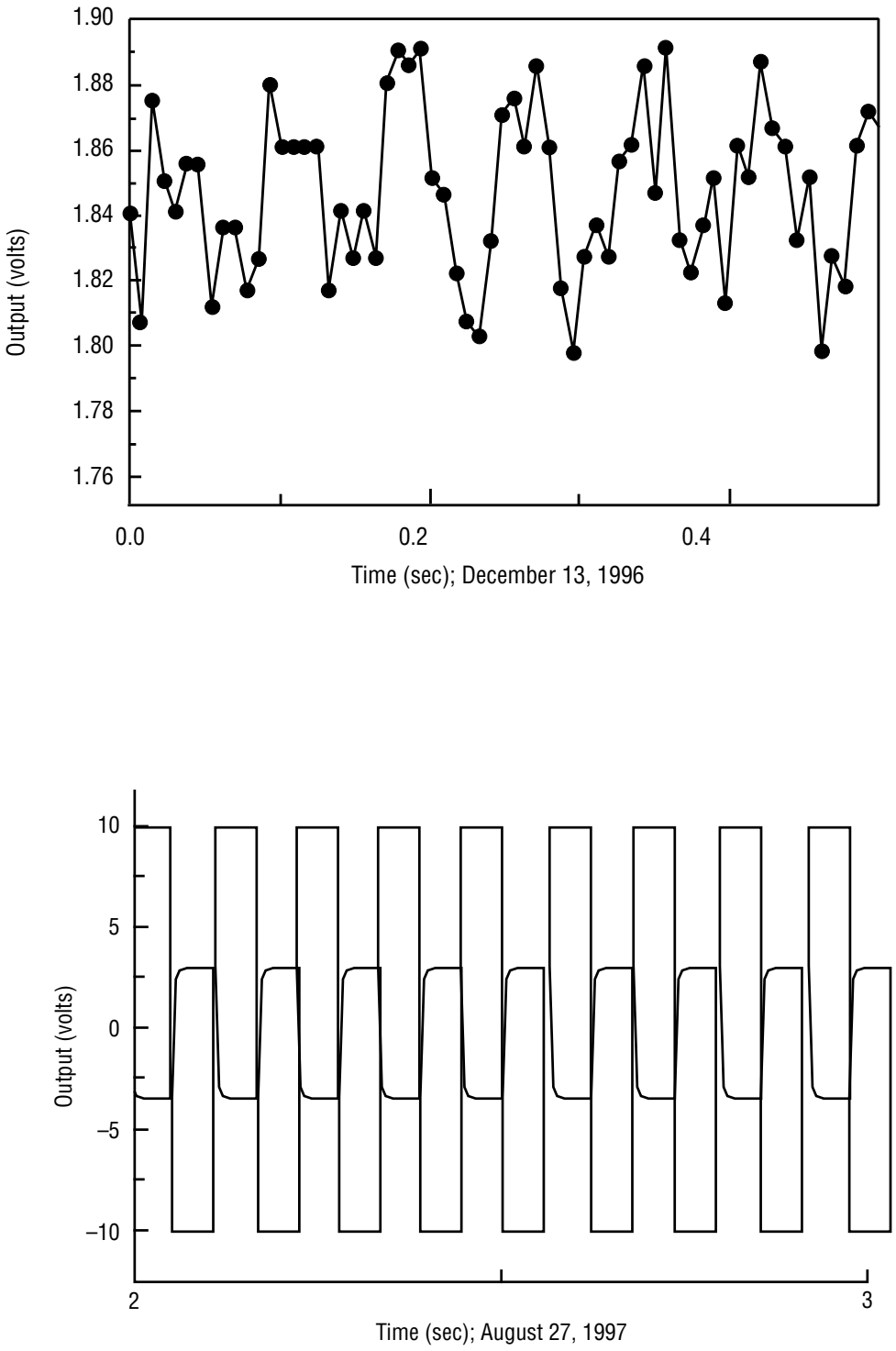


FIGURE 38.—Improvement in sensor output from 12/13/96 (top) to 8/27/97 (bottom). The improvement is due to a number of factors: better optical alignment, more laser power, larger aperture crystal, better amplifier offset adjust, more amplifier gain, front-end amplifier filters. In both cases, a +/-10 volt square wave was applied to the crystal; only the bottom plot shows the applied square wave.

Funding Summary ($k)

FY96	FY97
48k	26k

(~17k for co-I Solakiewicz)
(all obligated, no co-I support).

Status of Investigation

- Project approval date—October 1, 1996
- Estimated completion date—September 30, 1998
- Require this project to be continued into FY98 with additional FY98 funds of 9k.
  - — Additional KDP Crystal $3,500
  - — Calibration Function Generator (500V) $4,000
  - — Miscellaneous Optics (large area detectors, posts, holders) $1,500